Figure 1 – Group Delay Compensator
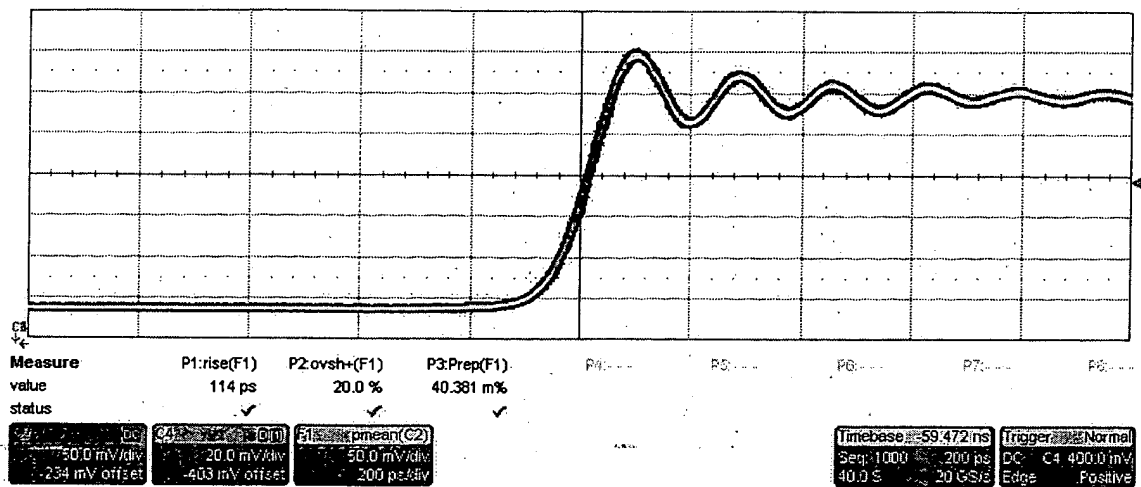
Figure 2 - WM8600A Channel Step Response Exhibiting Poor Group Delay Characteristics
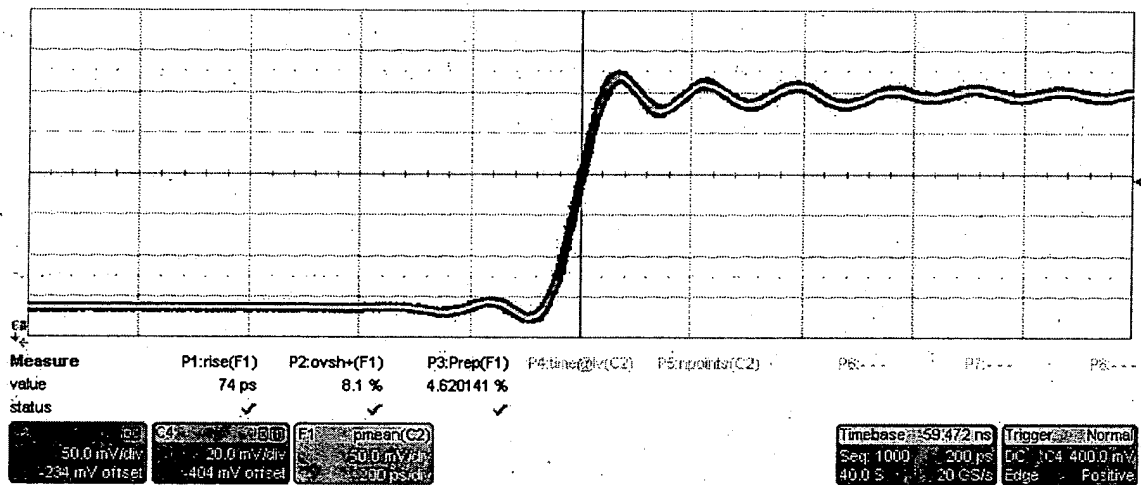

Figure 3 - WM8600A Channel Step Response Resulting From Improper Group Delay Compensation
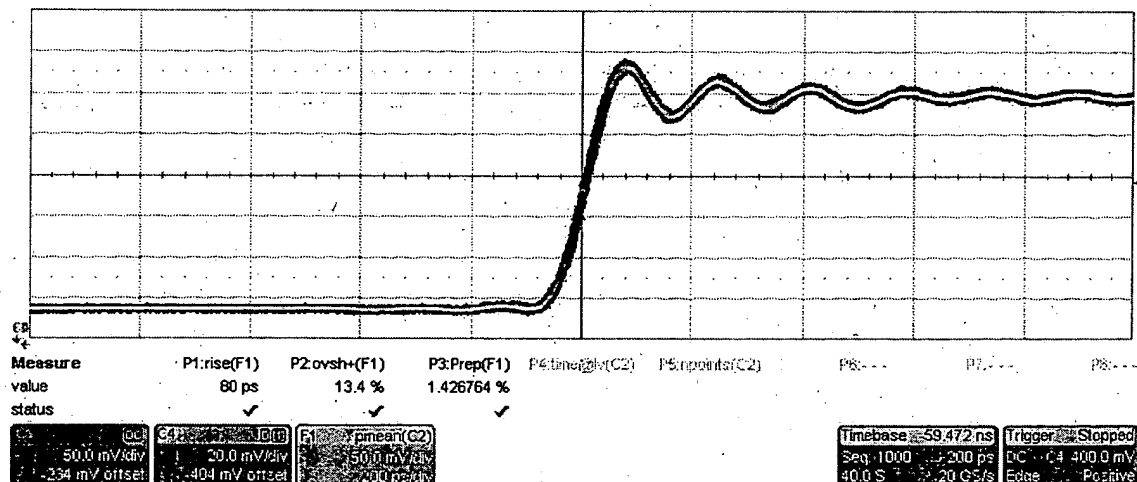

Figure 4 –WM8600A Channel Step Response with Proper Group Delay Compensation
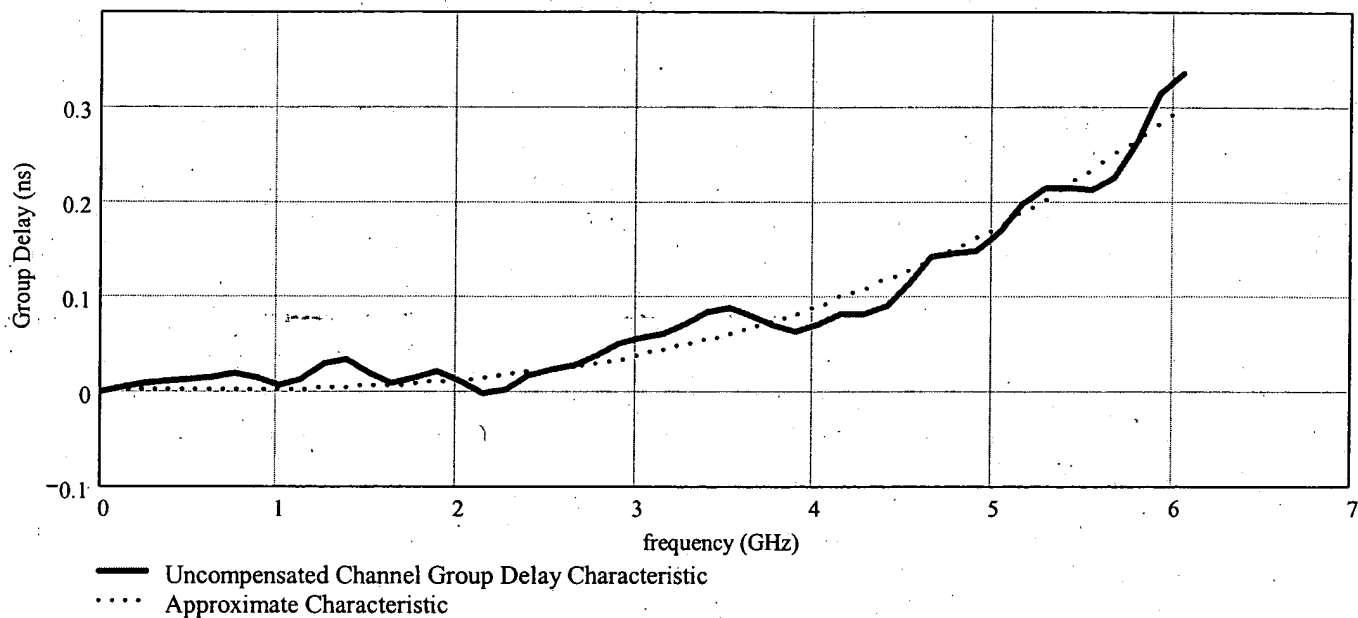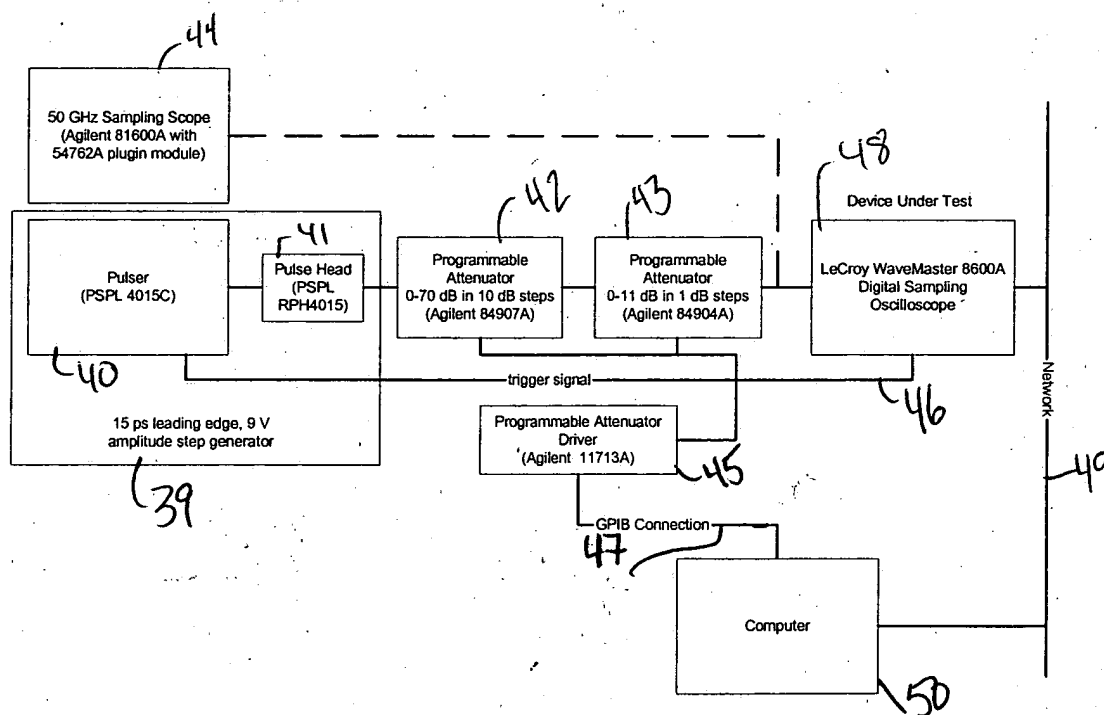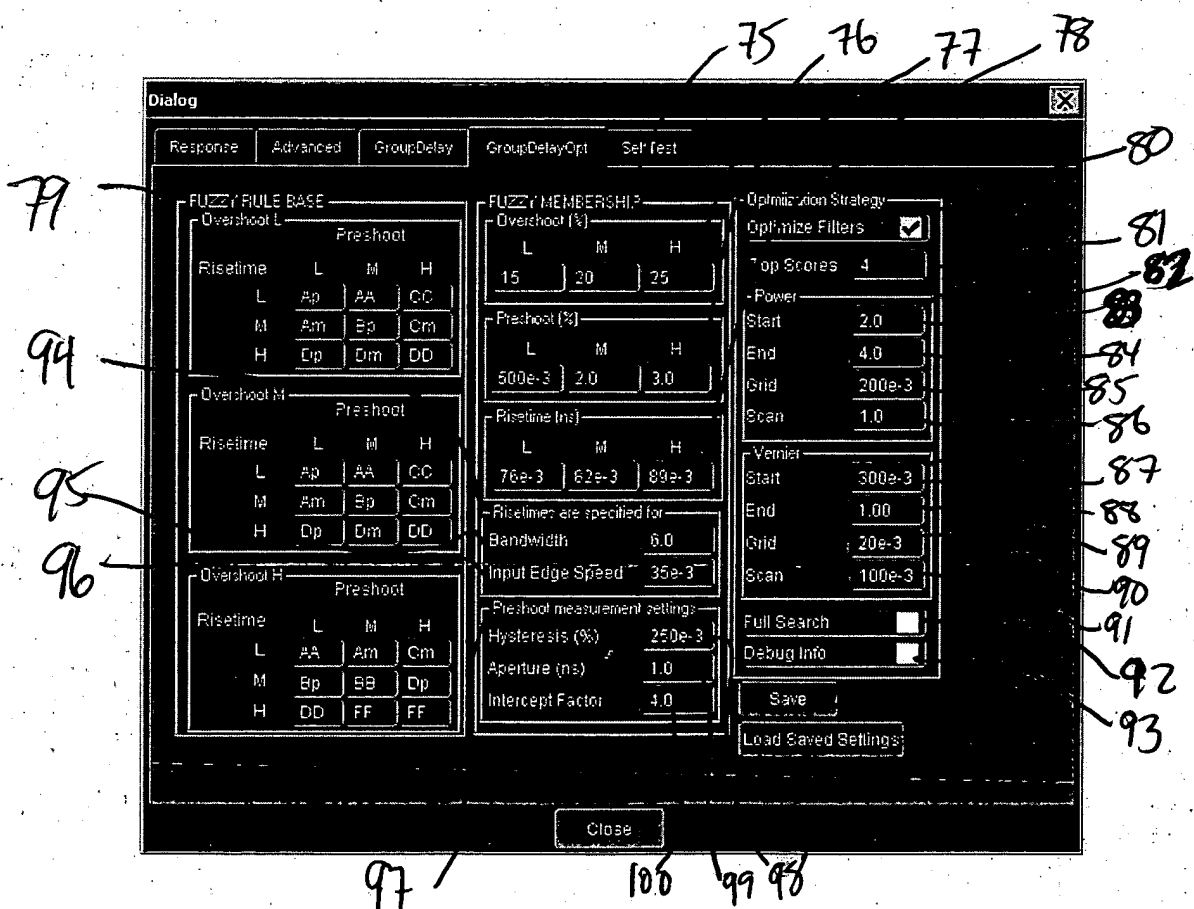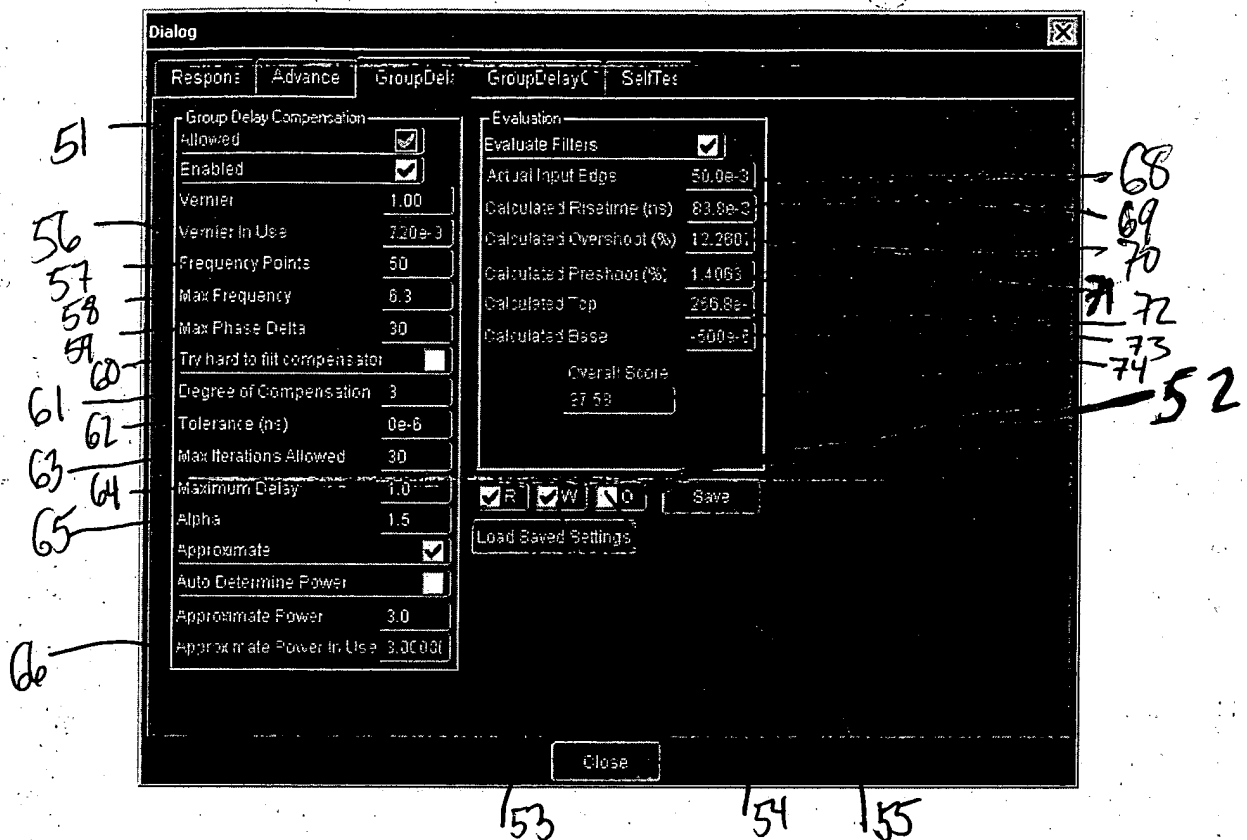
Uncompensated Channel Group Delay Characteristic
.... **Approximate Characteristic**

Figure 5 – Uncompensated Channel Group Delay Characteristic

Figure 6 – WaveMaster 8600A Calibration Arrangement

Figure 7

Dialog

Tabs: Respons | Advance | GroupDela | GroupDelayC | SelfTes

Group Delay Compensation

Allowed	☑
Enabled	☑
Vernier	1.00
Vernier In Use	7.20e-3
Frequency Points	50
Max Frequency	6.3
Max Phase Delta	30
Try hard to fit compensator	☐
Degree of Compensation	3
Tolerance (ns)	0e-6
Max Iterations Allowed	30
Maximum Delay	1.0
Alpha	1.5
Approximate	☑
Auto Determine Power	☐
Approximate Power	3.0
Approximate Power In Use	3.00001

Evaluation

Evaluate Filters	☑
Actual Input Edge	50.0e-3
Calculated Risetime (ns)	83.8e-3
Calculated Overshoot (%)	12.260
Calculated Preshoot (%)	1.4063
Calculated Top	266.8e-
Calculated Base	-500e-6

Overall Score

37.53

☑ R ☑ W ☐ O   Save

Load Saved Settings

Close

Figure 7 – Dialog Showing Allpass Filter Fitter options and Final Filter Evaluation

---

Figure 8

Dialog

Tabs: Response | Advanced | GroupDelay | GroupDelayOpt | Self Test

FUZZY RULE BASE

Overshoot L

Preshoot

Risetime	L	M	H
L	Ap	AA	CC
M	Am	Bp	Cm
H	Dp	Dm	DD

Overshoot M

Preshoot

Risetime	L	M	H
L	Ap	AA	CC
M	Am	Bp	Cm
H	Dp	Dm	DD

Overshoot H

Preshoot

Risetime	L	M	H
L	AA	Am	Cm
M	Bp	BB	Dp
H	DD	FF	FF

FUZZY MEMBERSHIP

Overshoot (%)

L	M	H
15	20	25

Preshoot (%)

L	M	H
500e-3	2.0	3.0

Risetime (ns)

L	M	H
76e-3	62e-3	89e-3

Risetimes are specified for

Bandwidth	6.0
Input Edge Speed	35e-3

Preshoot measurement settings

Hysteresis (%)	250e-3
Aperture (ns)	1.0
Intercept Factor	4.0

Optimization Strategy

Optimize Filters	☑
Top Scores	4

Power

Start	2.0
End	4.0
Grid	200e-3
Scan	1.0

Vernier

Start	300e-3
End	1.00
Grid	20e-3
Scan	100e-3

Full Search	☐
Debug Info	☐

Save

Load Saved Settings

Close

Figure 8 – Dialog Showing Grading Options and Optimization Strategy Options

#		Description
1	for n=0 ... N	for each response point
2	$R_n = GD_{comprel}(f_n, g_{i-1}) + gd_{spec_n}$	calculate a residual
3	for j=0 ... 2S-1	for each coefficient
4	$J_{n,j} = \dfrac{\partial}{\partial(g_{i-1})_j} GD_{comprel}(f_n, g_{i-1})$	calculate an element of the Jacobian matrix
5	$H = J^T \cdot W \cdot J$	calculate the approximate Hessian matrix
6	for j=0 ... 2S-1	generate a matrix whose diagonal is identical to the Hessian matrix and is zero elsewhere
7	$D_{j,j} = H_{j,j}$	
8	$\Delta P = (H + \lambda \cdot D)^{-1} \cdot J^T \cdot W \cdot R$	calculate the change in coefficient values
9	$g_i = g_{i-1} - \Delta P$	apply the change to the coefficients
10	$mse_i = \dfrac{1}{N+1} \cdot \sum_n \left(gd_{spec_n} + GD_{comprel}(f_n, g_{i-1})\right)^2$	calculate the new mean-squared error
11	true $mse_i > mse_{i-1}$ false	did the mean squared error increase?
12	$\lambda = \lambda \cdot 10$ favor steepest decent $\lambda = \dfrac{\lambda}{10}$ favor Newton-Gauss convergence	

Figure 9 – An Iteration of the Levenberg-Marquardt Algorithm during Allpass Filter Fit
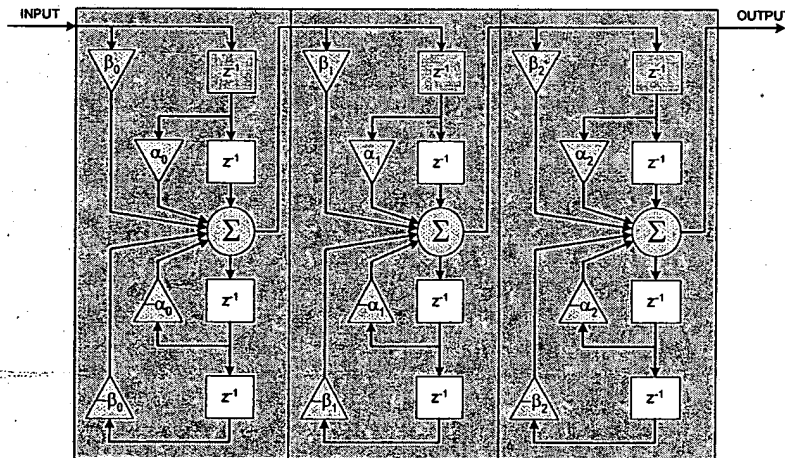
Figure 10 – A Three-Section (Sixth Order) Digital Allpass Filter

- ▬▬ Group Delay Compensation Specification
- • • • Group Delay of Allpass Filter Result From Filter Fitter
- ▬ ▪ ▬ Sum

- ▬▬ Compliance of Allpass Filter To Specification
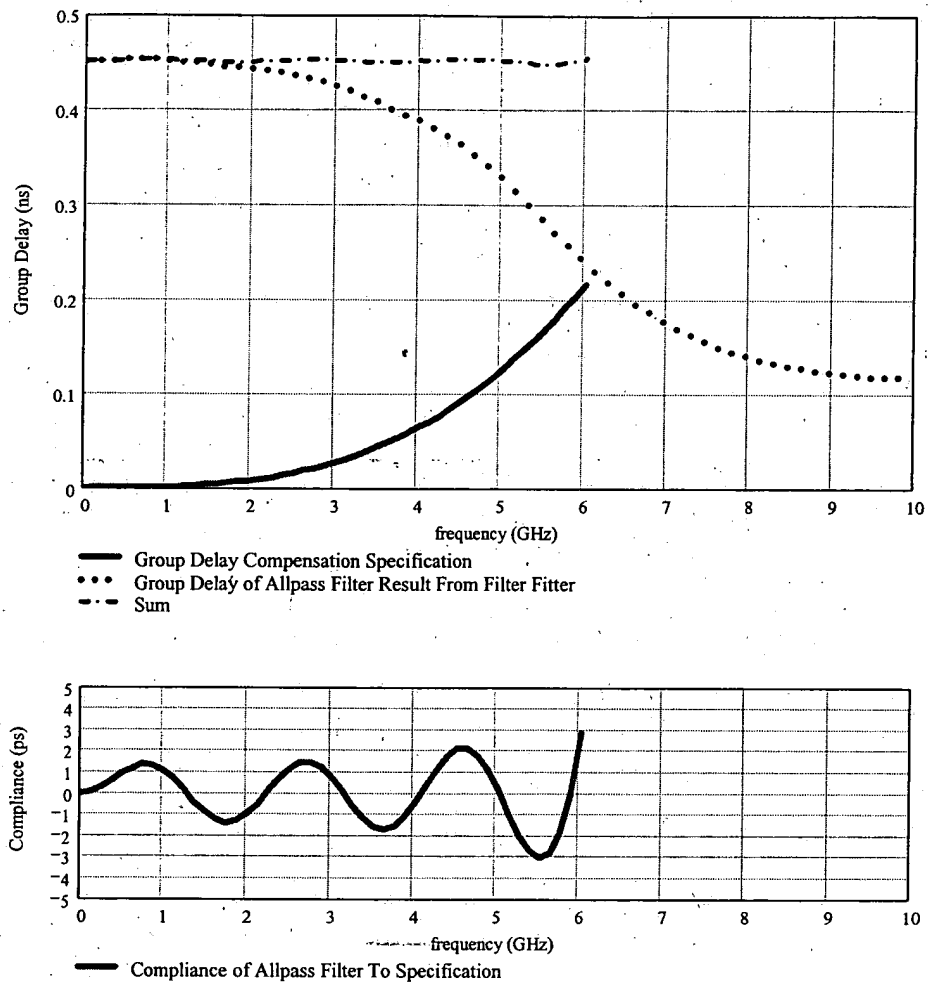
Figure 11 – Result of Allpass Filter Fit to Group Delay Compensation Specification

$$overshoot = \frac{max - top}{amplitude} \cdot 100\%$$

$$preshoot = \frac{max\_preshoot\_excursion}{amplitude} \cdot 100\%$$
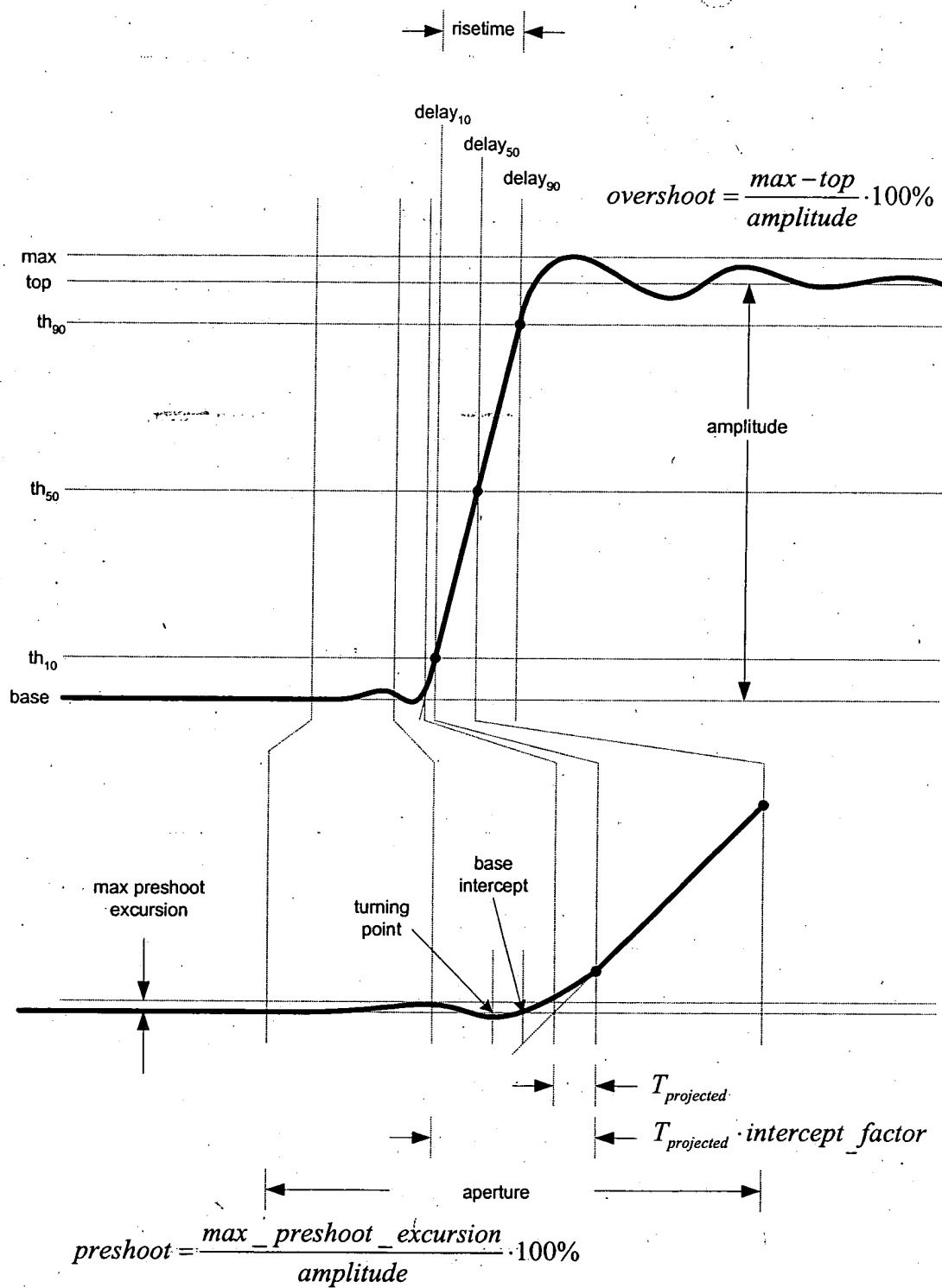
Figure 12 – Definitions of Risetime, Overshoot, and Preshoot Measurements
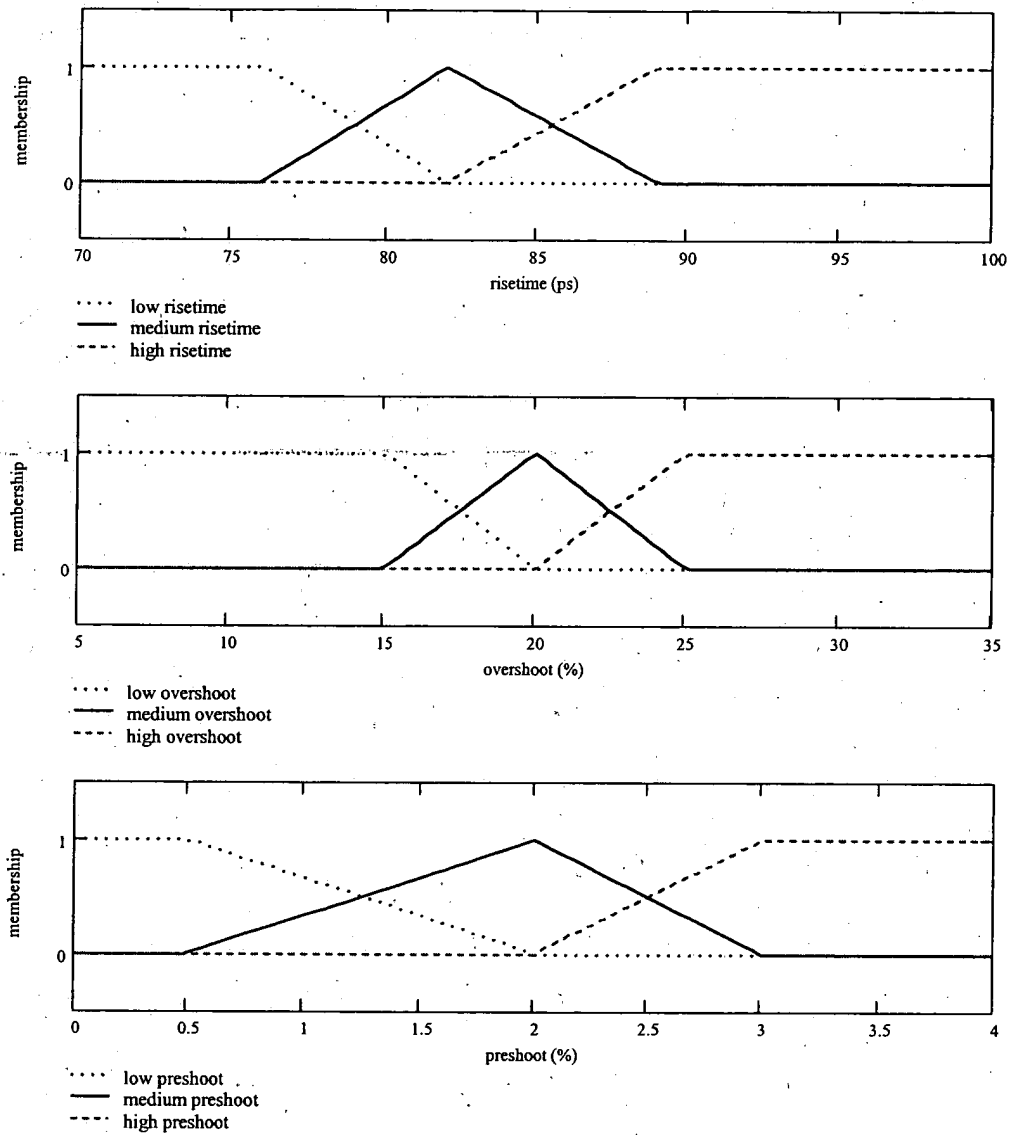
Figure 13 – Fuzzy Membership
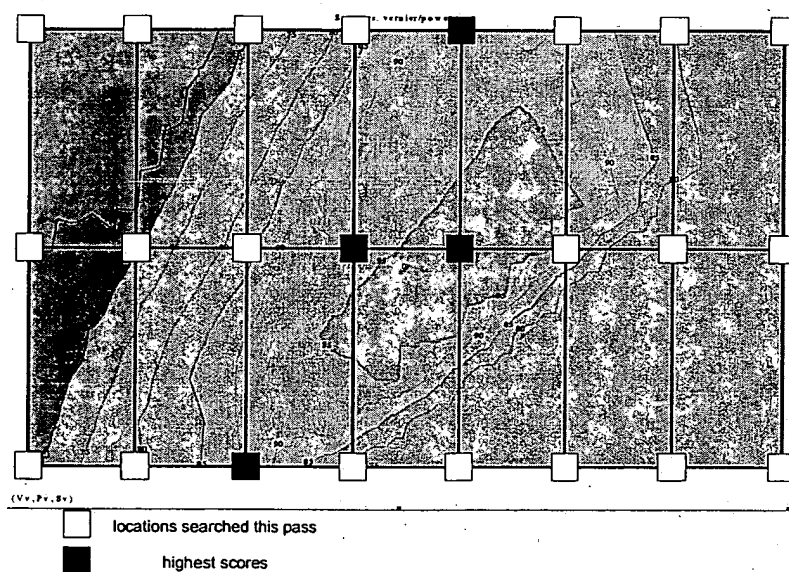
Figure 14 – Initial Optimization Scan and Result
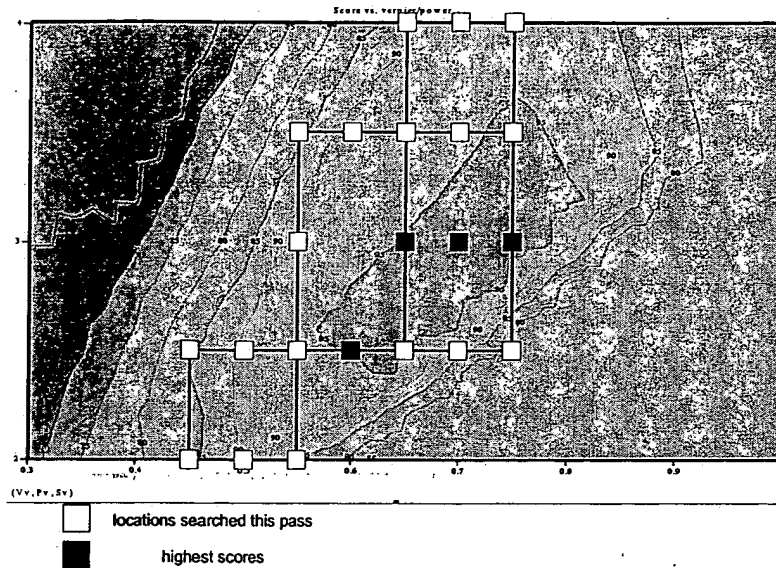
Figure 15 – Second Optimization Scan and Result
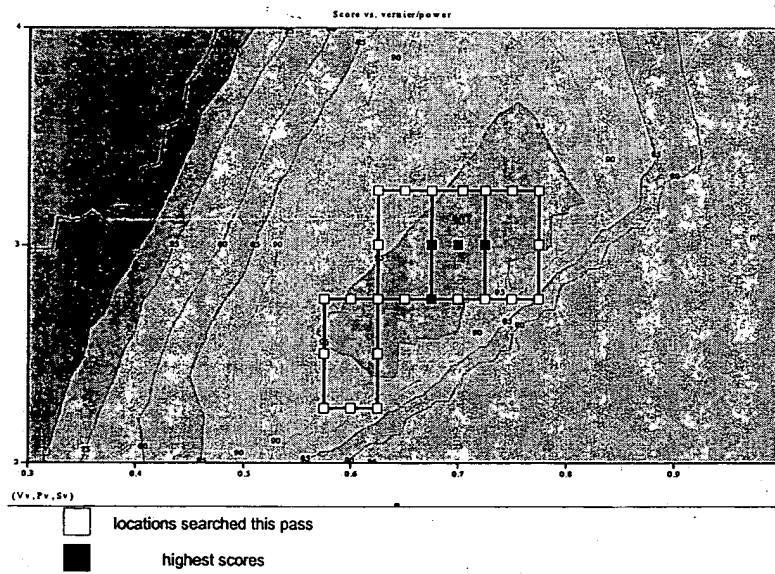
Figure 16 – Third Optimization Scan and Result
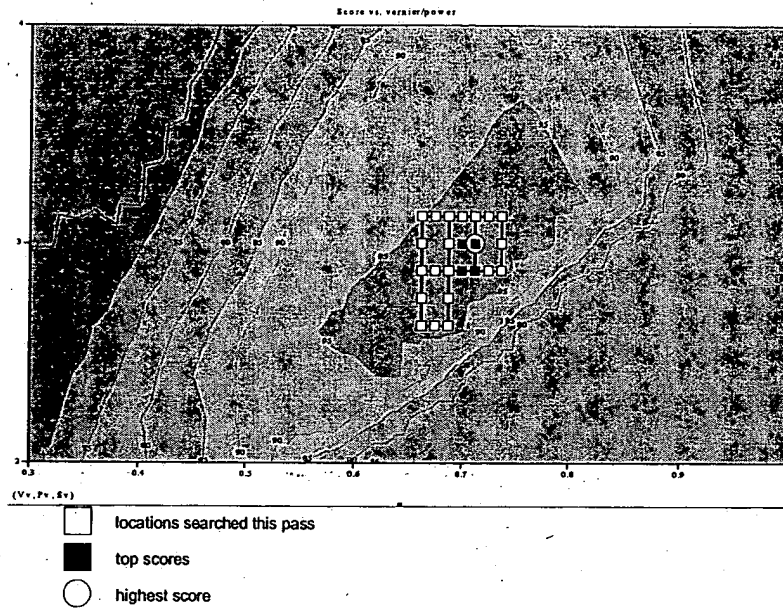
Figure 17 – Fourth Optimization Scan and Result
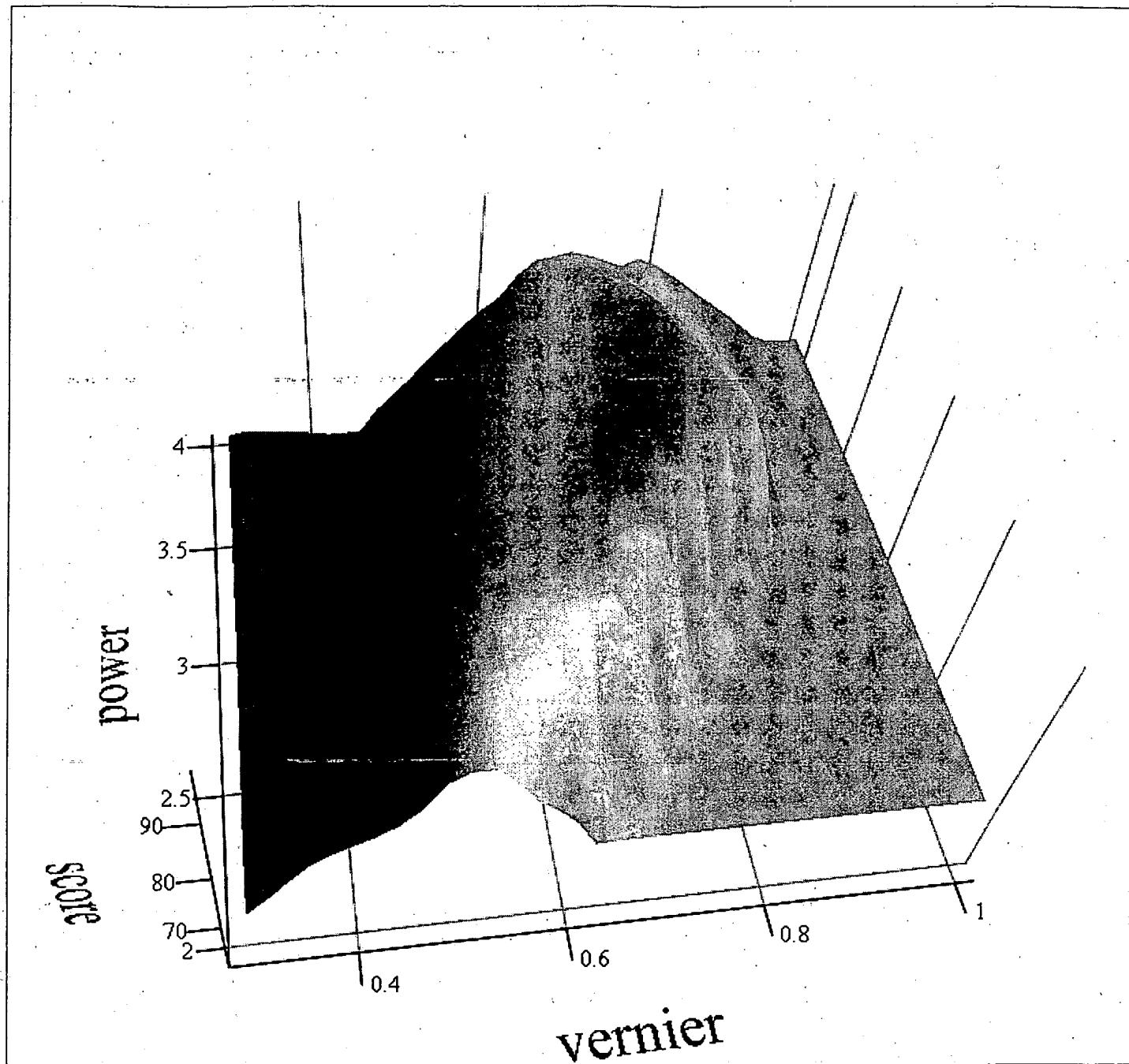
(Vv, Pv, Sv)

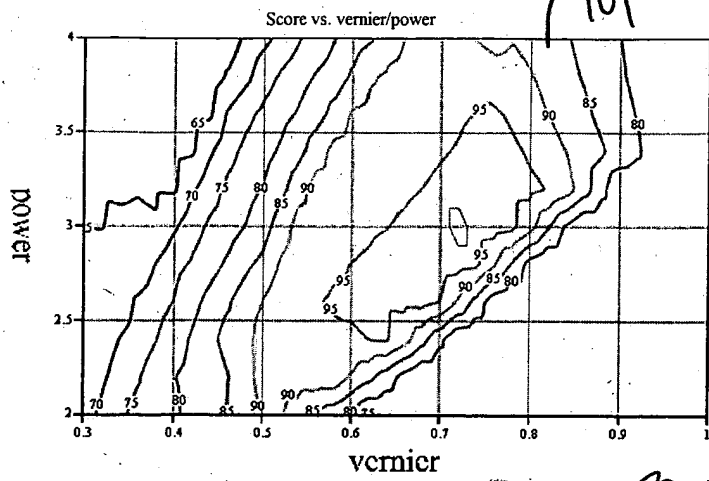**Figure 18 – Score vs. Optimization System Output Variables**
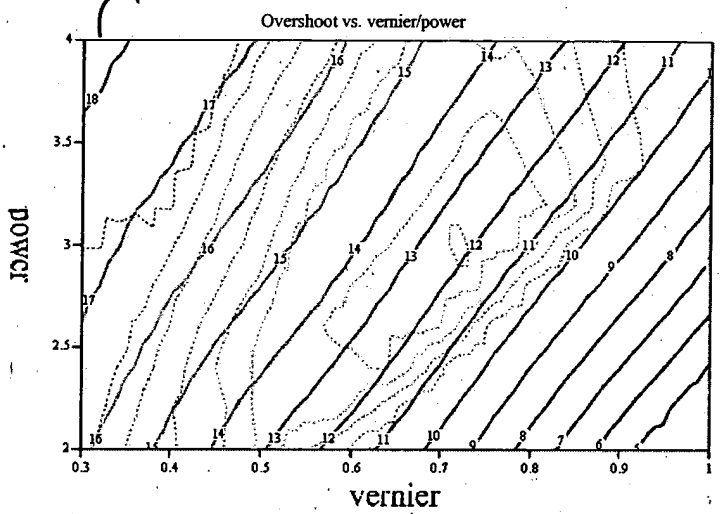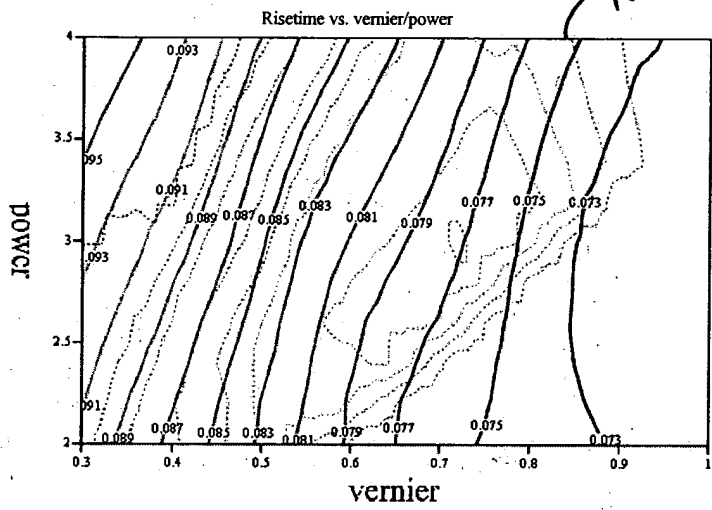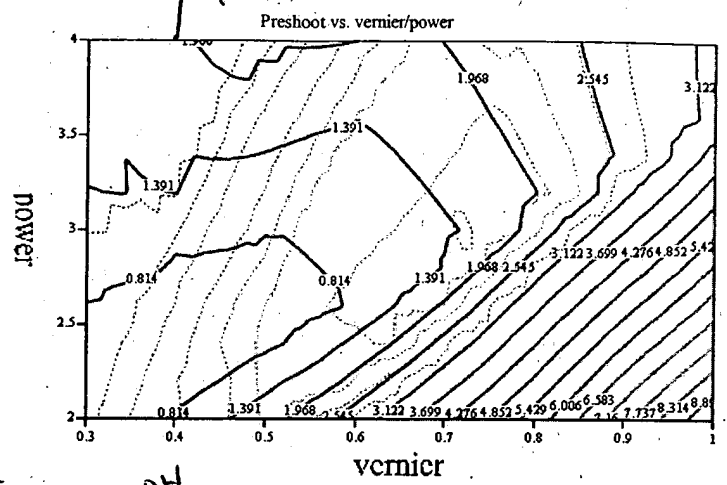
Figure 19 – Score and Measurer Parameter Outputs vs. Optimization System Output Control Variables
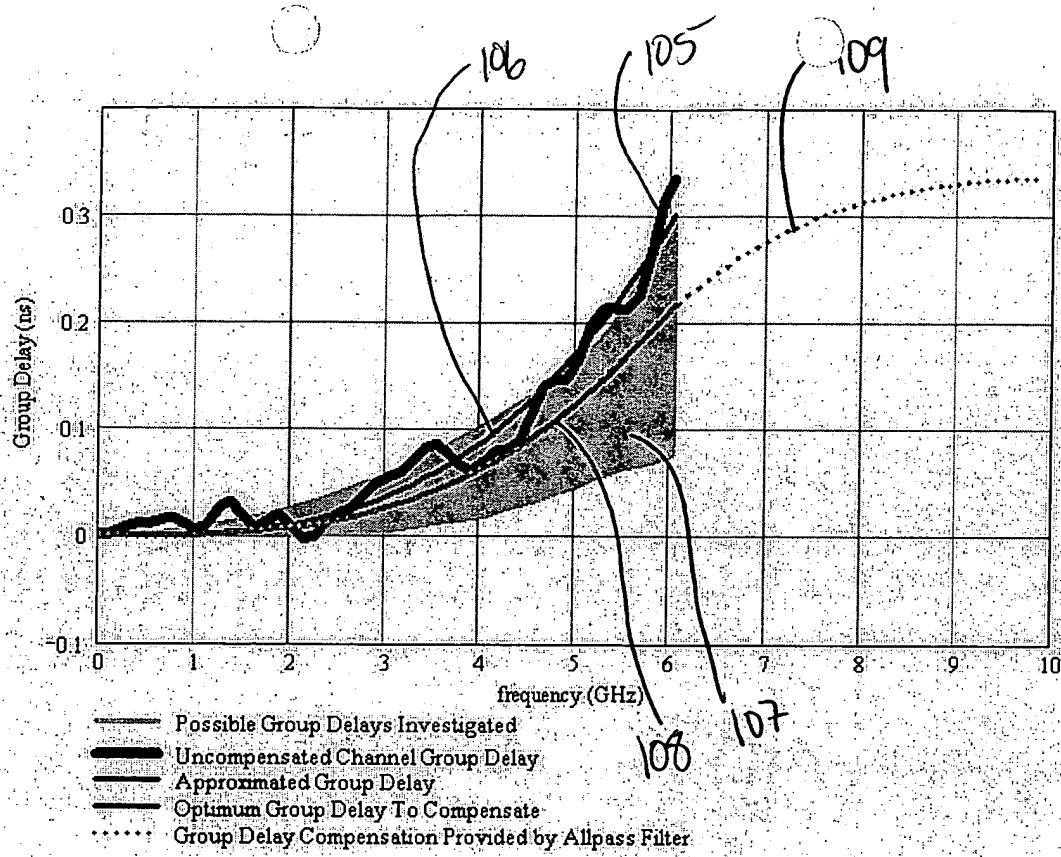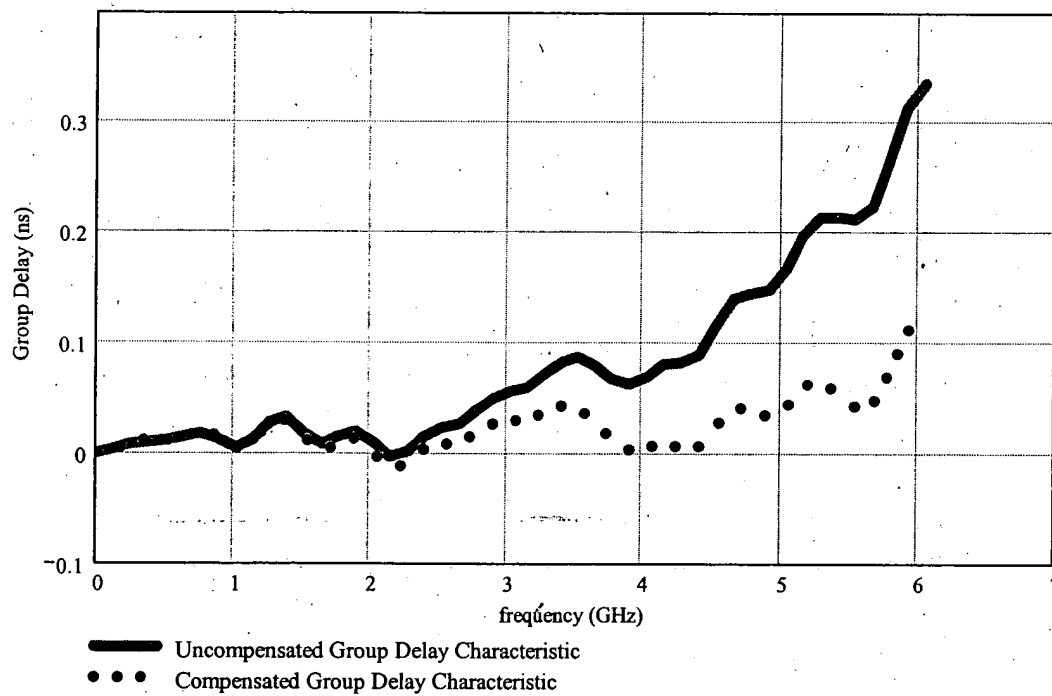
Figure 20 – Optimization Region and Result

Figure 21 – Comparison of Uncompensated and Compensated Group Delay